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A HISTOLOGIC STUDY ON THE RESPONSES OF PULP IN EXPERIMENTAL TOOTH MOVEMENT OF WHITE RATS

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》國文抄錄《

흰쥐의 實驗的 齒牙移動時 齒髓의 反應에 關한 組織學的 研究

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著者는 흰쥐 27首의 下顎第一大臼齒를 矯正用 고무線으로 移動시킨후, 移動의 初期에 나타나는 齒髓의 反應을 組織學的 方法으로 觀察하는 것을 研究目的으로 하였다.

30 Gm부터 120 Gm까지의 힘을, 12首는 3日間, 15首는 7日間, 各 實驗齒牙에 賦與하였다.

觀察結果는 다음과 같았다.

1. 齒髓組織의 主變化는 齒髓血管의 循環障碍와 造象牙細胞의 空胞形成으로 나타났다.
2. 適用시킨 힘의 增加에 따라서 上記 組織變化의 範圍가 擴大되었다.
3. 其外에 齒根의 象牙質과 白堊質의 部分的 吸收도 볼 수 있었다.

The field now known as orthodontics is as old as dentistry itself, but orthodontics as a specialty in a modern concept have been developed since the year 1900 when the Angle School of Orthodontia was founded. The school produced many men who were later to be remembered as pioneers of orthodontics. Besides these men, there were many investigators who sought the answers to the questions how the tooth and surrounding tissues reacted, or what the optimal force was.

In these studies the following have been found:

(1) In the periodontal membrane, compression or hyalinization in pressure side and stretching in tension side.

(2) In alveolar bone, resorption in pressure side and remodeling in tension side.

(3) The optimal force was equivalent to the capillary pulse pressure. [3) 5) 9) 10) 12) 13)]

However, surprising fact was found that few works dealing with changes of the tooth per se was performed. Studies by Marshall,[5] Oppenheim,[8] Butcher and Taylor,[1] Stenvik and Mjör,[10] and others signify that orthodontic forces may lead to regressive changes in pulp tissue including circulatory disturbances, calcifications and even pulp necrosis.

If the periodontium were the ground, a tooth would have been a tree to be replanted.

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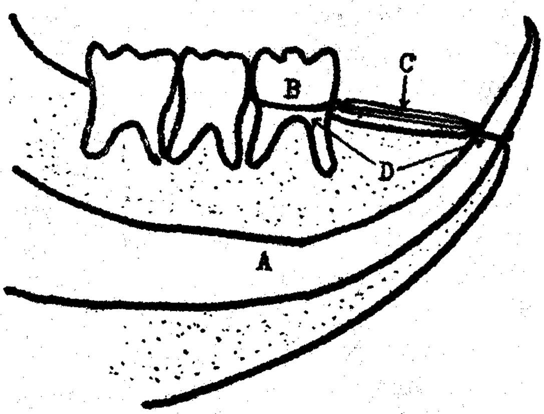
It ought to be studied the reactions of the teeth with the pulp and the dentine for the establishment of a perfect biologic basis in orthodontic treatment. Therefore, this report is to deal with a histologic evaluation of the initial responses in the pulp and dentine following the experimental tooth movement.

MATERIAL AND METHODS

The material consisted of fifty-four clinically intact lower first molars from twenty-seven adult white rats weighing from 250 grams to 300 grams.

Twenty-seven of the teeth were selected at random and served as control material. The rest of the teeth received fixed experimental devices which exerted forces continuously. Forces were derived from orthodontic elastics manufactured by Rocky Mountain Co., U.S.A.. One end of the elastics was ligatured with 0.010 inch orthodontic ligature wire to the cervix of the lower first molar and the other end to the cervix of the lower incisor in same side (Fig. 1). The force was recorded, with a Dentrix measure, at the start of the experiment. The forces applied varied from 30 to 120 grams for the different teeth, and the



A: Incisor B: First molar
C: Orthodontic elastics D: Ligature wire

Fig. 1. Experimtenal device

experiment lasted from 3 to 7 days (Tab. 1). For 7 days group, the elastics were exchanged in 4th day.

Tabel 1. groups in each experimental period by forces applied.

Force	3 days term of Ex.	7 days term of Ex.
Below 50 Gm.	4 animals	5 animals
70 to 90 Gm.	4 animals	5 animals
160 to 120 Gm.	4 animals	5 animals

Since it was very hard for rat to masticate and swallow foods with elastics on bilateral side in narrow oral cavity, the contralateral tooth was used as control.

All the teeth went through the same histologic procedure. Immediately after sacrificing the animal, the mandibular bone with teeth was removed and placed in 10 per cent neutral buffered formalin and fixed for 48 hours. They were decalcified in 5.2 per cent nitric acid and embedded in paraffin. In details of the histologic technique the author followed usual procedures.[4] Serial sections were prepared 5 microns thick through the pulp in axio-mesio-distal direction and stained with hematoxylin and eosin. Seven sections from each tooth were examined.

The evaluation was carried out as a blind test by covering these parts of the sections which would indicate whether the tooth belonged to the experimental or the control group. All evaluations were made by the same one.

OBSERVATION

The teeth in the experimental group as a whole showed more marked circulatory disturbances and more vacuolization of the odontoblast layer than the control group. By subdividing the teeth in experimental series into group, depending on the forces employed and the duration of the experiment, it was found that the circulatory disturbance and the vacuolization were the most pronounced in the group with the longer term of the experiment and the greater force. While the control material usually showed normal histologic pattern (Fig. 2).

3 days term of the experiment:

Magnitude of force seemed to be related to the histologic changes of pulp. There was a tendency toward increased severity with increased force.

Forces from 70 to 90 grams resulted in an increased number of capillaries in pulp and these capillaries were filled with numerous red blood cells(Fig. 4). Sometimes as apparent swelling of the lining could be observed.

Odontoblasts in control were lined up regularly in palisade formation and incontinuous contacts (Fig. 2). While this arrangement became disoriented and discontinuous in pulp horn portion with forces from 70 to 90 grams (Fig. 3). Vacuolization in odontoblast layer appeared to be less in force from 70 to 90 grams than in force from 100 to 120 grams.

7 days term of the experiment:

In this experimental group, vacuolization appeared to be extensive on the coronal odontoblast layer(Fig. 5). Vacuolization in the odontoblast layer were significantly increased with increased force. In the deep pulp portion the edematous changes appeared with force from 70 to 90 grams(Fig. 5). Only one tooth resulted in necrosis(Fig. 6). Odontoblastic nuclei were displaced into the predentine in a few cases.

Capillaries of the pulp in this experimental group were almost engorged. Several specimens showed the hemorrhagic regions(Fig. 7).

It must be emphasized that in addition to vacuolization and circulatory disturbances, resorptions of cementum and dentine were in three teeth in the experimental material, and two teeth were distributed in the marginal region and one in bifurcated area(Fig. 8 & 9).

DISCUSSION

It is generally accepted that it is difficult to compare the results of biologic experiments carried out by investigators in the same field. Even when evaluating the same histologic sections, one may consider a reaction insignificant while others will term it moderate or severe. This personal differences in evaluation can never be avoided.

Elastic exchanges were based on the report of Kang.[2]

Langeland suggested that the occurrence of empty spaces and vacuoles in the pulp tissue and in the odontoblast layer dose not indicated the significant pulp reactions.[3] This is not confirmed by the present observations. But the present findings support by the reports of Marshall,[5] Oppenheim,[8] Butcher and Taylor,[1] Stenvik and Mjör,[10] who reported variable degrees of pulp damage as a result of orthodontic treatment. An increased number of capillaries was found in the odontoblast layer in the experimental material, particularly with the use of large forces. This suggests that the circulatory disturbance was a result of the experimental forces.

The frequency of resorption in the dentine and cementum was less than that reported by Stenvik and Mjör,[11] Massler and Malone,[6] and McLaughlin.[7] who found radiologic evidence of resorption in more than 90 per cent of teeth following orthodontic treatment. However, it is apparent from the comparison of experimental periods that the investigation periods in the present study may have been too short to display the full extent of the resorptions.

Even though no definite conclusions can be reached on the basis of the short-term experiment in the present study, the findings clearly indicate that further research in this field, is needed.

SUMMARY

The author investigated on the responses of pulp and dentine following tooth movements. The material consisted of fifty-four intact teeth from twenty-seven adult white rats. The half of the teeth were employed as controls and the other half served as experimental group. These teeth were moved with forces ranging from 30 grams to 120 grams for from 3 to 7 days. All these were extracted immediately after the force was relieved.

The main pulp changes in the experiment were vacuolization of the pulp tissue and circulatory disturbances.

The magnitude of the force had an important role.

In addition to these changes, the resorption in dentine and cementum was observed, which was related to the magnitude of the force and the duration of experiment.

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REFERENCES

1) Butcher, E.O., and Taylor, A.C.: The vascularity of the incisor pulp of the monkey and its alteration by tooth retraction, J.D. Res. 31:239-247, 1952.

2) Kang, H.K.: An experimental study on the efficiency of orthodontic elastics, The New Medical Journal 12:903-908, 1969.

3) Langeland, K.: Effect of various procedure on the human dental pulp, Oral Surg,. Oral Med. & Oral Path. 14:210-233, 1961.

4) Lillie, R.D.: Histopathologic technic and practical histochemistry, London, 3rd ed., McGraw-Hill Book Co.

5) Marshall, J.A.: A study of bone and tooth changes incident to experimental tooth movement and its application to orthodontic practice, Int. J. ORTHODONTICS 19:1-17, 1933.

6) Massler, M. and Malone, A.J.:Root resorption in human permanent teeth; a roentgenographic study, AM.J. ORTHODONTICS 40:619-633, 1954.

7) Mc.Laughlin, K.D.: Quantitative determination of root resorption during orthodontic treatment, AM.J. ORTHODONTICS 50:143, 1964.

8) Oppenheim, A.: Human tissue response to orthodontic intervention of short and long duration, AM.J. ORHTODONTICS 28:263-301, 1942.

9) Reitan, K.: Bone formation and resorption during reversed tooth movement, VISTAS IN ORTHODONTICS, Philadelphia, 1962, Lea & Febiger.

10) Reitan, K.: Clinical and histologic observation on tooth movement during and after orthodontic treatment, AM.J. ORTHODONTICS 53:721-745, 1966.

11) Stenvik, A., and Mjör, I.A.: Pulp and dentine reactions to experimental tooth intrusion, AM.J. ORTHODONTICS 57:370-385, 1970.

12) Tayer, H.B., Gianelly, A.A., and Ruben, M.P.: Visualization of cellular dynamics associated with orthodontic tooth movement, AM.J. ORTHODONTICS 54:515-520, 1967.

13) Utley, R.K.: The activity of alveolar bone incident to orthodontic tooth movement as

studied by oxytetracycline induced fluorescence, AM. J. ORTHODONTICS 54:167-201, 1967.

14) Schwarz, A. M.; Über die Bewegung belasteter Zähne, Zeitschrift f. Stomatol., 26:40-83, 1928.

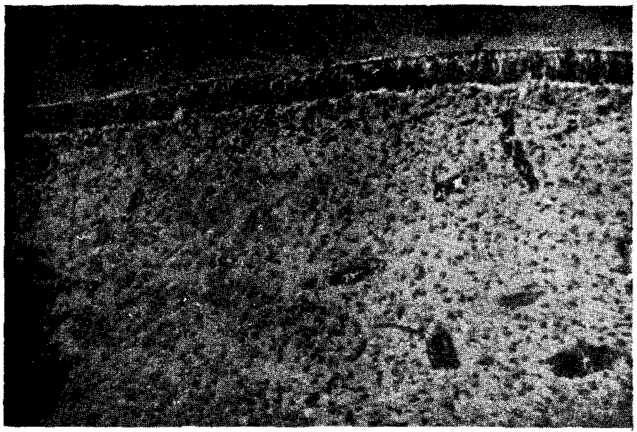

Fig. 2. Normal pulp of rat.

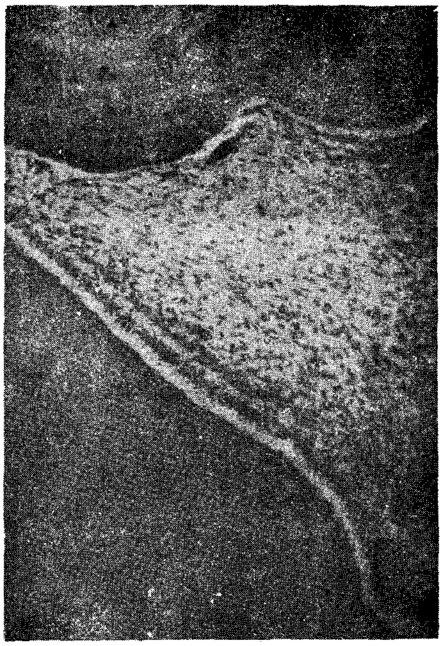

Fig. 3. Notice the discontinuous odontoblast layer in pulp horn.

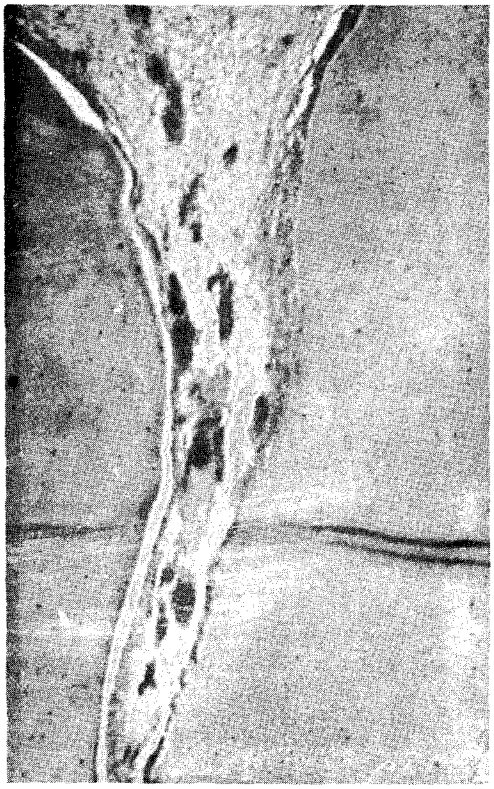

Fig. 4. Capillaries are filled with numerous red blood cells.

Fig. 5. Vacuolization and discontinuation on the coronal odontoblast layer.

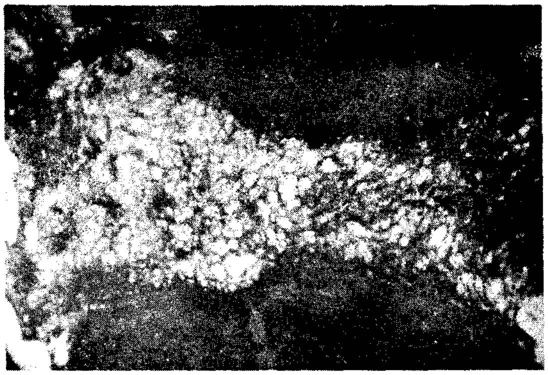

Fig. 6. Showed reticular atrophy.

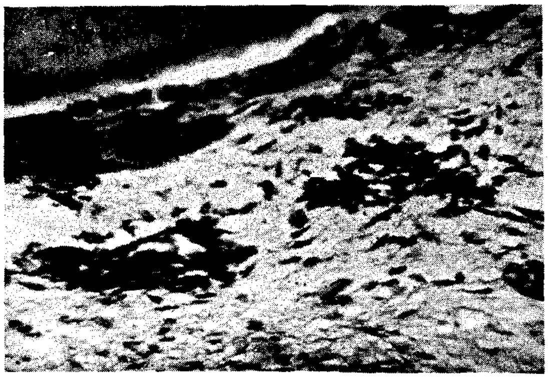

Fig. 7. Hemorrhagic region

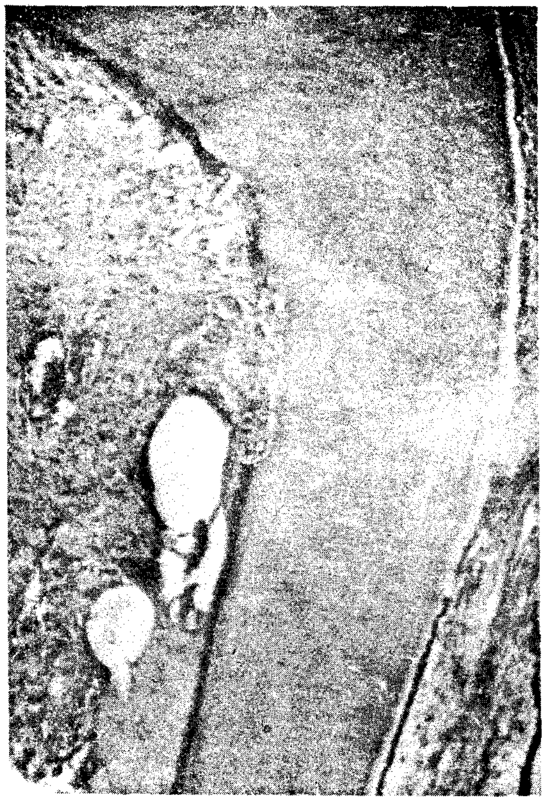

Fig. 8. Resorption of cementum and dentine in bifurcated area.

Fig. 9. Resorption in marginal area